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THESIS

A MANPOWER TRAINING REQUIREMENTS MODEL
FOR NEW WEAPONS SYSTEMS, WITH APPLICATIONS
TO THE INFANTRY FIGHTING VEHICLE

by

Douglas J. Kenehan

December 1981

Thesis Advisor: K. T. Marshall

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This thesis documents the methodology and parameters used in designing a manpower training requirements model for new weapons systems. This model provides manpower planners with the capability of testing alternative fielding policies and adjusting model parameters to improve the use of limited personnel resources. Use of the model is illustrated in a detailed analysis of the planned introduction of the Infantry Fighting

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A Manpower Training Requirements Model for New Weapons Systems, with Applications to the Infantry Fighting Vehicle

by

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

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TABLE OF ABBREVIATIONS AND ACRONYMS

ALO	Authorized Level of Organization
BN(s)	Battalion(s)
CAPT	Captain USA
CONUS	Continental United States
ETS	Estimated Termination of Service
FY	Fiscal Year
HQTRS	Headquarters
IFV	Infantry Fighting Vehicle
INF	Infantry
ITG	Infantry Training Group
LT	Lieutenant USA
MAJ	Major USA
MECH	Mechanized
MICV	Mechanized Infantry Combat Vehicle
MILPERCEN	Military Personnel Center
MOS	Military Occupational Specialty
NETT	New Equipment Training Team
OSUT	One Station Unit Training
POMCUS	Prepositioning of Materials Configured to Unit Sets
TO & E	Table of Organization and Equipment
TRADOC	Training and Doctrine Command

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I. INTRODUCTION

A. PROBLEM

The Defense Manpower System is essentially a closed hierarchical structure that is subject to the constant changes in the economy and in government policies. A dynamic environment such as this routinely dictates that a manpower manager possess the capability of rendering not only timely, accurate, and decisive solutions to immediate personnel problems, but also of preparing to forecast and analyze long-range effects of available alternatives.

One of the driving forces behind military policy change in the 1980's is the modernization of combat forces, using the latest technology in weapons and equipment [Ref. 1: p. 22].

An excellent case in point is the introduction of a new innovative weapons system known as the Infantry Fighting Vehicle (IFV), or "Bradley," into the Army's inventory. This vehicle will replace the Army's M113 armored personnel carrier. Over the next nine years, 4,175 IFV's will be produced and fielded, of which 2,352 will be manned and operated by U.S. Army personnel in 10 of 16 divisions located both in CONUS and Europe. Inherent with the vehicles' advanced operational characteristics, the current enlisted infantryman's military occupational specialty (MOS)[1] of 11B will be changed to 11M. In addition, revised personnel strength

---

[1]MOS is a term used for classifying military positions and personnel by occupational specialty. The two numbers identify the career management field, followed by a letter which further specifies skill requirements. For example, the MOS of 11B identifies the individual as a basic Infantryman, whereas the Fighting Vehicle Infantryman is classified as an 11M [Ref. 2: p. 169].

allowances for both enlisted personnel and officers will be authorized to units receiving the new weapons systems. Adequate numbers of IFV's will be produced commencing in fiscal year 1983 to convert approximately 41 conventional Mechanized Infantry Battalions into IFV Battalions [Ref. 3].

A number of enlisted personnel (to be determined) currently possessing the 11B MOS will need to be retained into the 11M MOS. Dependent on future requirements and loss rates, designated numbers of enlisted and officer personnel will need to be fed into the IFV training pipeline each year.

B. BACKGROUND

The Infantry Fighting Vehicle, then known as the Mechanized Infantry Combat Vehicle (MICV), had its origins in the 1960's when the Army adopted a tactical doctrine which called for its mechanized infantry forces to fight both mounted and dismounted. It quickly fell on hard times, however, owing to the Army's primary nonconventional mission in Vietnam [Ref. 4: p. 28].

Kindled by growing global tensions and the devastatingly lethal Arab-Israeli War of 1973, a renewed interest was born in the mid-1970's concerning the utility and capabilities of ground forces when equipped with the state-of-the-art weaponry. Dictated by national commitments and the increasingly prevalent threat of a tank and mechanized infantry conflict of high risk in Europe, the need for force-modernization became obvious.

The army's force-modernization plan for the future, Army 86, is founded upon advanced battlefield concepts, incorporates developmental

weapons and equipment, and takes maximum advantage of scarce manpower resources [Ref. 1: p. 23].

Studies were initiated by the Army's Training and Doctrine Command (TRADOC) under the direction of General Donn A. Starry in April 1976, to determine if the current division organization that was designed in the 1960's could efficiently use the combat power of modern weaponry, or whether reorganization of these elements was warranted [Ref. 1: p. 23].

Following a thorough study of the threat facing the U.S. Army divisions in a NATO scenario, and the integration of advanced material systems, operational concepts and human resources needed to counteract that threat, the battlefield development plan known as Division 86 was adopted in August 1978. This plan focuses on the need for firepower, survivability, and mobility on the modern battlefield [Ref. 1: p. 24].

The reorganization of divisional units outlined in the Division 86 plan is portrayed in Figure 1. (Division Support and Service units have been omitted.) Also from this figure, it should be evident that two of the major developmental systems behind the Army's new reorganization plan are the XM1 Abrams tank and its infantry counterpart, the XM2 IFV.

The Infantry Fighting Vehicle carries a crew of 9 personnel: vehicle commander (designated grade of E6), gunner (E5), driver (E4), rifle squad leader (E5), and 5 infantrymen ranging in grades from E1 to E4. Firepower capabilities of the IFV include a 23mm main gun, 7.62mm coaxial machine gun, dual-tube antitank missile launcher, and six 5.56mm modified M16 port weapons (used by the infantry squad during mounted operations). The IFV can travel at speeds of up to 41 MPH over rough terrain and is capable of negotiating water obstacles [Ref. 5: pp. 27-29].

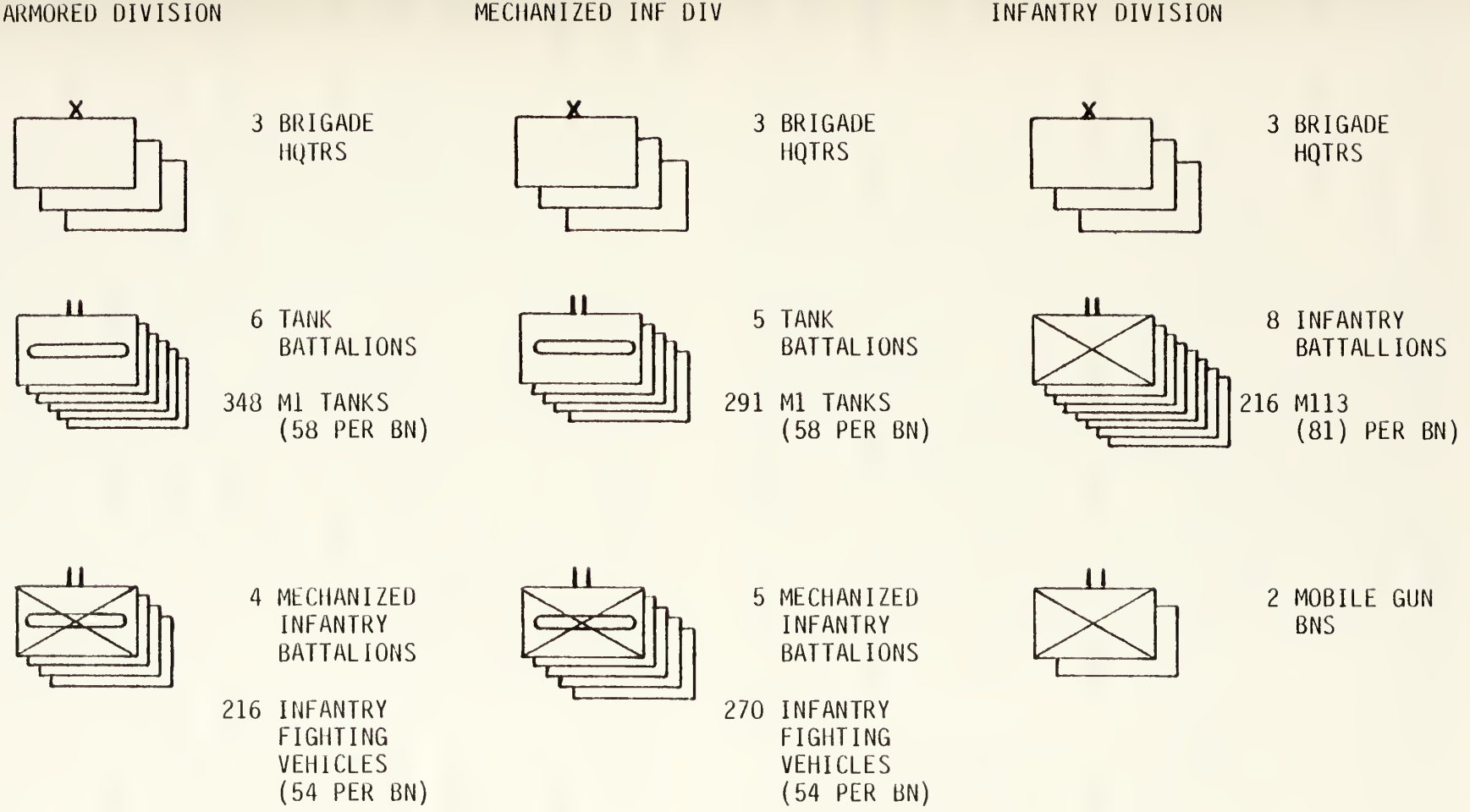
ARMORED DIVISION
MECHANIZED INF DIV
INFANTRY DIVISION
3 BRIGADE HQTRS
3 BRIGADE HQTRS
3 BRIGADE HQTRS
6 TANK BATTALIONS
348 M1 TANKS (58 PER BN)
5 TANK BATTALIONS
291 M1 TANKS (58 PER BN)
8 INFANTRY BATTALLIONS
216 M113 (81) PER BN)
4 MECHANIZED INFANTRY BATTALIONS
216 INFANTRY FIGHTING VEHICLES (54 PER BN)
5 MECHANIZED INFANTRY BATTALIONS
270 INFANTRY FIGHTING VEHICLES (54 PER BN)
2 MOBILE GUN BNS

Fig. 1. New Armored, Mechanized Infantry, and Infantry Division Configurations from the Division "86" Developmental Plan.

Production of the IFV is currently underway with delivery dates to designated CONUS and Europe units commencing in the early months of fiscal year 1983.

The Army's approach for incorporating these vehicles into its inventory over the next nine years is to transition approximately 41 Mechanized Infantry Battalions to IFV Battalions, using a 91-person new equipment training team (NETT). In addition, the Army's Infantry Schools, located at Fort Benning, Georgia, have established IFV training programs for all grades to include officers. The school has also been tasked by the Department of the Army (through TRADOC) to provide the necessary trained manpower to upgrade and maintain these IFV Battalions at an ALO-2 (authorized level of organization) strength level, according to the J. series Table of Organization and Equipment (TO & E) [Ref. 3].

C. OBJECTIVE

The purpose of this thesis is to design a manpower model to forecast training requirements for the introduction of new weapons systems such as the IFV. The model is designed to provide the manpower manager with another tool in planning for future policy changes. The model incorporates the following variables: total requirements (by grade) based on the IFV's production schedule and authorized strength levels; a parameter that encompasses retention, reclassifications, retirements, and promotions; and personnel transitioned (by grade) based on the number of battalions transitioned and average personnel strength in each battalion. In addition, the model provides IFV planners with the following results: training load requirements for both the One Station Unit Training (OSUT) 11M and the Infantry Officer Basic Courses

for fiscal years 1982 through 1990, in-route (transient) course training load requirement for the enlisted E5 through E8 and Officer 03 and 04 grade levels, and instructor requirements based on a predetermined student-to-instructor ratio, for both the Infantry Training Group (ITG) and the Weapons Training Group at Fort Benning's Infantry School.

II. INFANTRY FIGHTING VEHICLE MODEL

A. INTRODUCTION

Managing the limited military personnel resources of the 1980's warrants new and improved methods of manpower planning and forecasting. All too often, manpower management is reactive in nature, requiring immediate response to existing or imminent problems by policy managers with limited and often incomplete information. At best, this leads to the use of shortsighted patchwork methods which often prove inadequate in the long run. A manpower model can help to preclude such situations by providing policy managers with the necessary tools capable of improving the use of available manpower in present and future scenarios [Ref. 6: p. 70].

The development and use of manpower planning models within the U.S. Army would provide policymakers with the capability of early detection and selection of appropriate responses to potential manpower problems. In addition, adaptation of these models to existing computer technology could significantly enhance the policy-making process, offering considerable savings in time and accuracy. There is, however, an inherent human shortfall associated with the acceptance of any computer-driven model. All too frequently, after the model has become a part of an established system, the policy-maker blindly accepts the computer's results without understanding what the model does and why [Ref. 7: p. xx].

In an attempt to overcome this shortfall, Section II discusses in some detail the logic and method used in designing the IFV model.

B. MODEL DESCRIPTION

A mathematical model is the structuring of a set of pertinent parameters arising from a given problem into a mathematical equation. In its mathematical form the model can then be used to assist in solving that problem. The IFV Model is designed to structure the parameters that affect manpower input requirements for the U.S. Army's Infantry Fighting Vehicle.

Manpower input requirements for all grades can be fulfilled in several ways: from the outputs of the 11M OSUT and Officer basic courses, in-route transient courses for E5 through E8 and senior officer grades, and from the retraining of entire units by the NETT teams.

The following parameters are used in the model: total number of personnel from all ranks required; number of new recruits, both officers and enlisted personnel, needed for the different training pipelines; number of personnel trained in this specialty from the previous time periods; and the number of personnel transitioned (retrained by the NETT team) into this specialty during the given time period.

In an organization such as the U.S. Army where the manpower flow is continuous and dynamic, it becomes extremely difficult to determine the impact of policy changes. Experts have found that an effective method of studying a system such as this is to assume a state of equilibrium (steady state). The examination of the equilibrium consequences of any fixed policy is essential in uncovering the direction of change implied by the policy and for discovering the policy's long-run implications [Ref. 7: pp. 9-11].

The underlying rule governing a manpower flow system in a state of equilibrium is that inputs must equal outputs. Placing the paramaters of the IFV problem into a formula reflecting a state of equilibrium results in the following expression:

TOTAL NUMBER OF 11M PERSONNEL REQUIREMENTS (BY GRADE) IN A GIVEN TIME PERIOD	=	NUMBER OF 11M PERSONNEL INPUT (BY GRADE) DURING THAT TIME PERIOD	+	NUMBER OF 11M PERSONNEL (BY GRADE) REMAINING IN THE SYSTEM FROM THE PREVIOUS TIME PERIOD	+	NUMBER OF 11B PERSONNEL (BY GRADE) TRANSITIONED INTO THE 11M SPECIALTY DURING THAT TIME PERIOD	(1)

For ease of manipulation, notation is introduced to represent the various factors in expression (1). Lower case letters refer to scales or vectors, and upper case letters refer to matrices. Subscripts will be introduced later in this section to denote rank or grade. The lower case letter (t) will be used to index discrete time periods (e.g., fiscal years 1982 through 1990).

An additional variable must be incorporated into the model that accounts for the gain and loss of personnel by rank from one period to the next. It is unrealistic to assume, for example, that all personnel within the IFV specialty field would still be in the system at the end of any given time period.[2] Likewise, on-hand strength figures of personnel retrained by the NETT teams during that year would have been affected by such things as retirement, service or MOS transfer, termination of service (ETS), and promotions. To model these dynamic fluctuations, a matrix Q is used which accounts for period-to-period fractional flows.

---

[2]There is one exception to this statement. The IFV Model assumes that new officer and enlisted recruits remain in service for at least one time period.

1. Mathematical Notation

The following mathematical notation is used in the IFV model.

For the enlisted personnel in the 11M specialty[3], let

$r_1(t)$ = requirements at time t in grades E1 through E4,

$r_i(t)$ = requirements at time t in grades i+3, i=2,3,4,5,

$f_1(t)$ = input flow into grades E1 through E4, in time period t,

$f_i(t)$ = input flow into grades i+3 in time period t i=2,3,4,5,

$c_1(t)$ = number transitioned from 11B into the 11M specialty in grades E1 through E4 in time period t,

$c_i(t)$ = number transitioned from 11B into the 11M specialty in grades i+3 in time period t, i=2,3,4,5,

$s_1(t)$ = stock of personnel in the 11M specialty in grades E1 through E4 in time period t,

$s_i(t)$ = stock of personnel in the 11M specialty in grades i+3 in time period t, i=2,3,4,5.

From these, the four 5-dimensional column vectors are constructed.

$$r(t) = \begin{pmatrix} r_1(t) \\ r_2(t) \\ r_3(t) \\ r_4(t) \\ r_5(t) \end{pmatrix},$$

For example:

$$\text{enlisted requirements in fiscal year 1982 (t=1)} = \begin{pmatrix} 475 \\ 217 \\ 133 \\ 23 \\ 9 \end{pmatrix} \begin{matrix} \text{E1/E4} \\ \text{E5} \\ \text{E6} \\ \text{E7} \\ \text{E8} \end{matrix},$$

$$f(t) = \begin{pmatrix} f_1(t) \\ \cdot \\ \cdot \\ \cdot \\ f_5(t) \end{pmatrix}, \quad c(t) = \begin{pmatrix} c_1(t) \\ \cdot \\ \cdot \\ \cdot \\ c_5(t) \end{pmatrix}, \quad s(t) = \begin{pmatrix} s_1(t) \\ \cdot \\ \cdot \\ \cdot \\ s_5(t) \end{pmatrix}.$$

---

[3]Enlisted grade E-9 (Battalion Sergeant Major) was not included in the analysis. One Battalion Sergeant Major is authorized per IFV Battalion.

In addition, let

q_{ij} = fraction of personnel that are in grade j at time t that are in grade i at time t+1.

This is assumed to be constant over time (i.e., independent of the particular time period t). Now let Q be the 5 x 5 matrix depicting the historical movement of enlisted personnel from period to period

$$Q = \begin{bmatrix} q_{11} & \cdots & q_{15} \\ \vdots & & \\ q_{51} & \cdots & q_{55} \end{bmatrix} .$$

The IFV model uses a lower triangular Q matrix that allows personnel advancement of at most one grade in a time period. For example:

$$Q = \begin{array}{c} \\ \text{E1/E4} \\ \text{E5} \\ \text{E6} \\ \text{E7} \\ \text{E8} \end{array} \begin{array}{c} \begin{array}{ccccc} \text{E1/E4} & \text{E5} & \text{E6} & \text{E7} & \text{E8} \end{array} \\ \begin{bmatrix} 0.65 & -- & -- & -- & -- \\ 0.11 & 0.50 & -- & -- & -- \\ -- & 0.22 & 0.76 & -- & -- \\ -- & -- & 0.12 & 0.80 & -- \\ -- & -- & -- & 0.11 & 0.73 \end{bmatrix} \end{array} .$$

The above matrix shows that in one year, 65 percent of the E1 through E4 personnel would remain in those grades; only 11 percent would be promoted to E5, and 24 percent would leave. Likewise, 50 percent of the personnel currently holding the rank of E5 remain in that grade, 22 percent move on to the grade of E6, and 28 percent leave.

Using this notation, the mathematical expression of flows spelled out in equation (1) becomes:

$$r(t) = f(t) + Qs(t-1) + Qc(t), \qquad (2)$$

or mathematically rearranged,

$$f(t) = r(t) - Qs(t-1) - Qc(t), \; t = 1,2,\ldots 9. \qquad (3)$$

In equation (3), r(t) is determined from the current TO & E and the IFV production schedule. The Q is derived from past personnel

data, and the c(t) from a dictated transition schedule and current on-hand Mechanized Infantry Battalion personnel strengths. At time t = 0, it is assumed that s(0) is equal to 0; i.e., there are no personnel trained in the 11M MOS at time 0. The vectors f(1), f(2),....f(9) and s(1), s(2),....s(9) are calculated alternately. Since all flows must be positive (i.e., personnel are not forced out of the system involuntarily), any calculated negative flows are replaced by zero flows. Calculations proceed as follows:

(i) Calculate $f(1) = [r(1) - Qc(1)]^{+}$.

The notation $[\quad]^{+}$ means that any negative element of the vector in the parenthesis is replaced by a zero. For example, if

$$r(1) = \begin{pmatrix} 100 \\ 80 \\ 50 \\ 20 \\ 10 \end{pmatrix} \quad \text{and} \quad Qc(1) = \begin{pmatrix} 70 \\ 65 \\ 55 \\ 30 \\ 10 \end{pmatrix} ,$$

$$\text{then } [r(1) - Qc(1)]^{+} = \begin{pmatrix} 30 \\ 15 \\ 0 \\ 0 \\ 0 \end{pmatrix} .$$

(ii) Calculate $s(1) = f(1) + Qc(1)$.

(iii) Calculate $f(2) = [r(2) - Qs(1) - Qc(2)]^{+}$.

(iv) Calculate $s(2) = f(2) + Q[s(1) + c(2)]$.

Steps (iii) and (iv) are then repeated for time periods 3 through 9.

Mathematical notations for the officer personnel model[4] are similar to that of the enlisted personnel model, with these exceptions.

---

[4]Officer grades O-1 (Second Lieutenant) and O-2 (First Lieutenant) were combined into one class (Lieutenant). The grade of O-4 (Lieutenant Colonel) was not included in the analysis. One Battalion Commander is authorized per IFV Battalion.

Instead of five classes (grades), three classes are used resulting in four three-dimensional column vectors:

$$r(t) = \begin{pmatrix} r_1(t) \\ r_2(t) \\ r_3(t) \end{pmatrix},$$

For example:

officer requirements in fiscal year 1982 (t=1) = $\begin{pmatrix} 35 \\ 15 \\ 3 \end{pmatrix}$ $\begin{matrix} \text{LT} \\ \text{CPT} \\ \text{MAJ} \end{matrix}$,

$$f(t) = \begin{pmatrix} f_1(t) \\ f_2(t) \\ f_3(t) \end{pmatrix}, \quad c(t) = \begin{pmatrix} c_1(t) \\ c_2(t) \\ c_3(t) \end{pmatrix}, \quad s(t) = \begin{pmatrix} s_1(t) \\ s_2(t) \\ s_3(t) \end{pmatrix}.$$

The matrix Q becomes a 3 x 3 depicting historical movement data of officers personnel from period to period.

$$Q = \begin{bmatrix} q_{11} & q_{12} & q_{13} \\ q_{21} & q_{22} & q_{23} \\ q_{31} & q_{32} & q_{33} \end{bmatrix}.$$

Equation (3) is the governing mathematical model and calculation procedures (i) through (iv) still apply.

2. Q-Matrix Derivation

To establish the fractional flow Q matrix, personnel strength data were collected on officers in the 11 specialty career field (i.e., Infantry) and enlisted personnel in the 11B MOS. Since longitudinal data were not available on the historical movement of enlisted personnel in the 11M MOS, 11B data were used to forecast 11M personnel movement trends. Beginning strength, gains, losses, and end strengths for each grade level, by fiscal year, were tabulated for both officer and enlisted personnel. The beginning and end strength categories are self explanatory. Personnel gains were defined as anyone entering that grade level during that fiscal year through new accession, interservice transfer, reclassification, or promotion. Losses were those individuals that left this

grade level through ETS, reclassification, or promotion to the next grade.

a. Enlisted Matrix

The pertinent data collected on 11B enlisted personnel, (grade E1 through E8), fiscal year 1980, are depicted in Table 1. The data concerning grades E1 through E4 were consolidated to be consistent with the corresponding model notation.

TABLE 1

FISCAL YEAR 1980, 11B ENLISTED PERSONNEL DATA

Rank / Category	E1/E4	E5	E6	E7	E8
Begin Strength	41,639	6,875	6,088	4,222	2,121
Gains	15,405	4,353	1,527	774	475
Losses	14,366	3,489	1,455	904	563
End Strength	42,678	7,739	6,160	4,092	2,033

(Data provided by U.S. Army MILPERCEN)

From the data in Table 1, the numbers of personnel remaining in any particular grade, moving to the next higher grade and leaving the service, were computed using the following formulas:

$$\begin{aligned} &\text{Beginning strength within a given grade} \\ -\ &\underline{\text{Number of losses within that grade}} \\ =\ &\text{Number of personnel remaining in that grade} \end{aligned} \tag{4}$$

$$\begin{aligned} &\text{Number of personnel moving to the next grade (promoted)} \\ =\ &\text{the gains of the next highest grade} \end{aligned} \tag{5}$$

$$\begin{aligned} &\text{Number of losses in a given grade} \\ -\ &\underline{\text{Number of gains in the next highest grade}} \\ =\ &\text{Net losses to the service} \end{aligned} \tag{6}$$

$$\begin{aligned} &\text{Number of personnel remaining in that grade} \\ +\ &\text{Number of personnel moving to the next grade} \\ +\ &\underline{\text{Net losses to the service}} \\ =\ &\text{Total (beginning strength)} \end{aligned} \tag{7}$$

The results of these computations are displayed in the 5 x 5 data matrix of Table 2.

TABLE 2

ENLISTED PERSONNEL DATA MATRIX

		FROM				
		E1/E4	E5	E6	E7	E8
TO	E1/E4	27,273	0	0	0	0
	E5	4,353	3,386(A)	0	0	0
	E6	0	1,527(B)	4,633	0	0
	E7	0	0	744	3,318	0
	E8	0	0	0	475	1,558
	NET LOSSES	10,013	1,962(C)	681	429	563
	TOTAL	41,639	6,875(D)	6,088	4,222	2,121

Example of calculations (using E5 data):

	Beginning strength	6,875	
-	Number of losses	3,489	
	Number of E5's Remaining in grade	3,386	(A)
	Number of personnel promoted to E6 = E6 Gains	1,527	(B)
	Number of losses	3,489	
-	Number of promotions	1,527	
	Net losses to the service	1,962	(C)
	Number of E5's remaining in grade	3,386	
+	Number of E5's promoted	1,527	
+	Net losses to the service	1,962	
	Total (beginning strength)	6,875	(D)

The 5 x 5 fraction flow Q matrix in Table 3 was derived from Table 2.

TABLE 3

ENLISTED PERSONNEL Q MATRIX AND FRACTIONAL LOSSES

	E1/E4	E5	E6	E7	E8
E1/E4	0.655	--	--	--	--
E5	0.105	0.493	--	--	--
E6	--	0.222	0.761	--	--
E7	--	--	0.127	0.786	--
E8	--	--	--	0.113	0.735
NET LOSSES	0.240	0.285	0.112	0.101	0.265

Note: All columns add up to 1.000. Fractional net losses have been included for completeness; they are not part of the Q matrix.

Example of calculations (using E5 data):

$$\frac{\text{Number of E5's remaining in grade}}{\text{Total (beginning strength)}} \qquad \frac{3,386}{6,875} = 0.493$$

$$\frac{\text{Number of E5's promoted to E6}}{\text{Total (beginning strength)}} \qquad \frac{1,527}{6,875} = 0.222$$

$$\frac{\text{Net losses to the service}}{\text{Total (beginning strength)}} \qquad \frac{1,962}{6,875} = 0.285$$

b. Officer Matrix

The pertinent data collected on designated 11 specialty officer personnel (i.e., Lieutenant, Captain, and Major) from fiscal years 1977 through 1980 are depicted in Table 4.

TABLE 4

INFANTRY OFFICER PERSONNEL DATA

	Fiscal Year	1977	1978	1979	1980	Cumulative Total
LT	Beg. Str.	3,562	3,532	3,862	4,449	15,405
	Gains	1,011	1,070	1,118	1,025	4,224
	Losses	866	727	517	1,436	3,566
	End Str.	3,687	3,875	4,463	4,038	16,063
CPT	Beg. Str.	5,088	4,735	4,359	3,653	17,835
	Gains	712	527	276 ~~726~~	1,285	2,800
	Losses	986	904	968	962	3,820
	End Str.	4,814	4,358	3,667	3,976	16,815
MAJ	Beg. Str.	2,636	2,687	2,675	2,675	10,673
	Gains	544	446	569	640	2,199
	Losses	500	475	555	563	2,093
	End Str.	2,680	2,658	2,689	2,752	10,779

Note: Data provided by Officer Personnel Management Directorate (OPMD), MILPERCEN.

Aside from the use of four years of longitudinal data, the derivation of the officer Q matrix is identical to the process used in Section II, B2a (Enlisted Matrix). By using four years of data in lieu of one, historical movement of officer personnel was averaged into the resulting fractional flow matrix.

The column labeled "Cumulative Total" in Table 4 reflects the aggregate sum of each row. This column was used for the remaining officer Q matrix computations.

With the use of formulas (4) through (7), on page 26, the following 3 x 3 data matrix was derived:

TABLE 5

OFFICER PERSONNEL DATA MATRIX

FROM

TO		LT	CPT	MAJ
	LT	11,839	0	0
	CPT	2,800	14,015	0
	MAJ	0	2,199	8,580
	NET LOSSES	766	1,621	2,093
	TOTAL	15,405	17,835	10,673

(Beg. Str)

Example of calculations (using Captain data):

	Beginning strength	17,835
-	Number of losses	3,820
	Number of captains Remaining in grade	14,015

Number of personnel promoted to major = major gains 2,199

	Number of losses	3,820
-	Number of promotions	2,199
	Net losses to the service	1,621

	Number of captains remaining in grade	14,015
+	Number of captains promoted	2,199
+	Net losses to the service	1,621
	Total (beginning strength)	17,835

Using the numerical data from Table 5 results in the following 3 x 3 fraction flow Q matrix for officer personnel.

TABLE 6

OFFICER Q MATRIX AND FRACTIONAL LOSSES

	LT	CPT	MAJ
LT	0.768	--	--
CPT	0.182	0.786	--
MAJ	--	0.123	0.804
NET LOSSES	0.050	0.091	0.196

Note: All columns add up to 1.000. Fractional net losses have been included for completeness; they are not part of the functional Q matrix.

C. TIME LINE DIAGRAM

In an attempt to put the design of the IFV model into perspective, it is useful to analyze the time line diagram portrayed on the following page.

This diagram depicts the ten-year IFV planning cycle. Time period zero (t=0) refers to fiscal year (FY) 1981; the second time period (T=1) refers to FY 1982 and so on through the ninth time period (t=9) which would refer to FY 1990.

The models' objective is to determine what quantities of manpower need to be fed into the IFV training pipelines at the beginning of each fiscal year, to meet battalion strength requirements at the end of that fiscal year.

This diagram shows the personnel flow [f(0)...f(9)] with arrows, indicating inputs being fed in the beginning of each fiscal year. Realistically, these flows would be dispersed throughout the entire

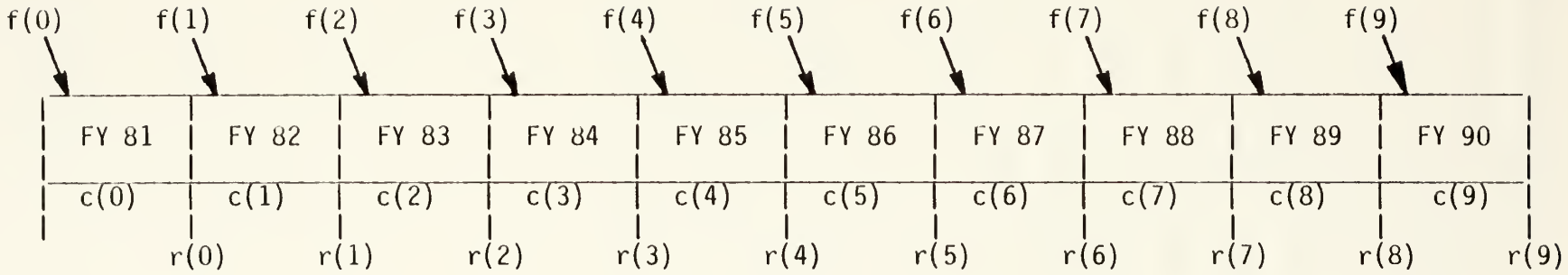

Figure 2. Time line diagram for the IFV model.

time period. Keeping the objective statement in mind, total requirements [r(0)....r(9)] are depicted at the end of each fiscal year.

To compensate for the rapid acceleration in total requirements as new IFV battalions are fielded, U.S. Army planners intend to transition or retrain a designated number of 11B personnel each year into the 11M specialty, using the NETT teams. The transition variables [c(0)....c(9)] are appropriately located in the center of each time period, signifying the on-going retraining of IFV personnel.

Logically, not all of the personnel who have previously been trained in any one fiscal year by either IFV programs located at Fort Benning, Georgia or retrained in field locations by NETT teams will remain in the 11M specialty for an indefinite period of time. An additional factor needs to be incorporated into the model which predicts these losses. The fractional flow (the Q matrix) is designed to forecast the historical movement trends of personnel within this specialty.

Toward this end, the IFV manpower model described in this Section was designed.

III. MODEL APPLICATION

A. INTRODUCTION

The vectors of total requirements r(t) and transitions c(t) are dependent largely on one planning dimension, the number of battalions fielded each fiscal year.[5] To illustrate the model's application, and in addition, provide a comparative analysis on resulting input requirements, two separate assumptions were pursued concerning the proposed fielding of the IFV.

1. Assumption 1 (A1)

Predetermined numbers of Mechanized (MECH) Infantry (INF) Battalions (BN's) would be issued IFV's from FY 1982 through FY 1990. The current production schedule would be reviewed to insure an adequate number of vehicles will be available for issue each fiscal year.

2. Assumption 2 (A2)

The annual production of IFV's would dictate the number of battalions fielded during any given fiscal year.

B. GENERAL INFORMATION

The material discussed in this section is common to both applications. The current production schedule for the IFV, dated 19 August 1981, is shown in Appendix A. Approximately 1,823 of the IFV's produced will not require manned crews (i.e., they would be used as floats, test

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[5] At the same time, a MECH INF BN is fielded (issued IFV's), all personnel within that battalion would be transitioned to the IFV occupational specialty 11M by the NETT team.

vehicles or placed in POMCUS storage.) Since unmanned vehicles are not relevant to the models application, they are omitted from the computations. An abreviated version of Appendix A has been provided below.

TABLE 7

IFV PRODUCTION SCHEDULE: FY 1982 THROUGH FY 1990
(IFV'S REQUIRING CREWS)

Fiscal Year	82	83	84	85	86	87	88	89	90
Army Schools	47	32	3	16	26				
CONUS Cmbt. Unit		108		136	108	216	229	203	80
Europe Cmbt. Unit		68	108	108	28	216	188	216	216

NOTE: Figures based on vehicle receipt dates to units.

The vehicles designated for instructional use at U.S. Army schools have the following crew configuration:

E1/E4 - 1 each per vehicle (driver)
E5 - 1 each per vehicle (gunner)
E6 - 1 each per vehicle (commander)

Personnel allocations for vehicles being sent to combat units in CONUS and Europe are structured in accordance with the new IFV Battalions configuration (i.e., TOE 07-245J110, effective date 24 September 1981).

LT (01/02) - 23 each per 54 vehicles
CAPT (03) - 10 each per 54 vehicles
MAJ (04) - 3 each per 54 vehicles
E1/E4 - 264 each per 54 vehicles
E5 - 92 each per 54 vehicles
E6 - 36 each per 54 vehicles
E7 - 15 each per 54 vehicles
E8 - 6 each per 54 vehicles

The on-hand strength figures for units receiving the IFV are crucial in formulating the models' transition vector c(t). Enlisted and officer

personnel strength samples were taken from 10 Mechanized Infantry Battalions designated to be reconfigured into IFV Battalions in the near future. This sampling resulted in the following statistical data shown in Tables 8 through 10. The range shows the difference between highest and lowest strengths.

TABLE 8

ENLISTED ON-HAND STRENGTHS (CONUS)

Rank	Average	Standard Deviation	Range
E1/E4	289	43.66	83
E5	43	8.50	16
E6	32	7.93	15
E7	12	1.00	2
E8	4	0.58	1

Note: Averages were rounded up if > 0.1.

TABLE 9

ENLISTED ON-HAND STRENGTHS (EUROPE)

Rank	Average	Standard Deviation	Range
E1/E4	217	9.87	21
E5	43	4.84	13
E6	34	5.47	14
E7	10	1.33	4
E8	8	1.52	4

Note: Averages were rounded up if > 0.1.

TABLE 10

OFFICER ON-HAND STRENGTHS (COMBINED CONUS/EUROPE)

Rank	Average	Standard Deviation	Range
LT (01/02)	18	1.86	6
CAPT (03)	9	1.62	4
MAJ (04)	2	0.53	1

Note: Averages were rounded up if > 0.1.

The Officer data were combined into one table since on-hand strengths showed little differences between CONUS and Europe. The enlisted data, however, reflected a sizable deviation in the on-hand strengths of grades E1 through E4. For this reason, separate computations (for CONUS and Europe) were necessary in applying the IFV model to enlisted requirements. Computed data for enlisted personnel are shown in separate tables. For the purpose of demonstrating the IFV model, the assumption is made that the average on-hand strengths shown in Tables 8 through 10 would remain consistent throughout the ten year planning cycle.

C. APPLICATION OF ASSUMPTION 1

The following table shows the number of IFV Battalions fielded in CONUS and in Europe from Fiscal Year 1982 through 1990.

TABLE 11

IFV BATTALIONS FIELDED BY FISCAL YEAR

Fiscal Year	82	83	84	85	86	87	88	89	90
CONUS	0	1.5	0.5	2	2	4	4	4	2
EUROPE	0	0.0	3.0	2	0	4	3	4	5
TOTAL	0	1.5	3.5	4	2	8	7	8	7

(Data provided by the IFV Task Force located at Ft. Benning, Georgia)

1. Total Requirement Vector Computation r(t)

The following formula was used in calculating the total enlisted and officer requirements (by grade) during each fiscal year, for CONUS and Europe.[6]

$$\begin{array}{l}\text{TOTAL NUMBER OF PERSONNEL REQUIRED (BY FY AND GRADE)} \\ \text{AUTHORIZED IFV BN STRENGTH (BY GRADE)} \times \text{NUMBER OF IFV BN'S FIELDED (BY FY)} \\ + \text{SCHOOL IFV CREW STRENGTH (BY GRADE)} \times \text{NUMBER OF SCHOOL IFV'S RECEIVED (BY FY)}\end{array} \quad (8)$$

Results of the computations are shown in Tables 12, 13, and 14.

2. Transition Vector Computation c(t)

Since the number of Mechanized Infantry Battalions transitioned equals the number of IFV Battalions fielded each fiscal year, the data contained in Table 11 also apply to this section.

The following formula was used in calculating the total number of enlisted and officer personnel transitioned (by grade) during each fiscal year, for CONUS and Europe.

$$\begin{array}{l}\text{TOTAL PERSONNEL TRANSITIONED (BY FY AND GRADE)} \\ \text{NUMBER OF PERSONNEL BY GRADE ON-HAND (AVERAGE STRENGTH)} \times \text{NUMBER OF MECH INF BATTALIONS TRANSITIONED (DURING THAT GIVEN FY)}\end{array} \quad (9)$$

Results of the computations are shown in Tables 15, 16, and 17.

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[6]The portion of the formula dedicated to calculating personnel requirements for school IFV's only pertained to CONUS enlisted computations.

TABLE 12

TOTAL AND ADDITIONAL FY ENLISTED REQUIREMENTS BY GRADE: A1
(CONUS)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)
FY / Rank	1982	1983	1984	1985	1986	1987	1988	1989	1990
E1/E4	47 / 47	475 / 428	610 / 135	1154 / 544	1708 / 554	2764 / 1056	3820 / 1056	4876 / 1056	5404 / 528
E5	47 / 47	217 / 170	266 / 49	466 / 200	676 / 210	1044 / 368	1412 / 368	1780 / 368	1964 / 184
E6	47 / 47	133 / 86	154 / 21	242 / 88	340 / 98	484 / 144	628 / 144	772 / 144	844 / 72
E7	0 / 0	23 / 23	35 / 12	65 / 30	95 / 30	155 / 60	215 / 60	275 / 60	305 / 30
E8	0 / 0	9 / 9	14 / 5	26 / 12	38 / 12	62 / 24	86 / 24	110 / 24	122 / 12

NOTE: Total personnel requirements/additional FY requirements.

EXAMPLE:

ADDITIONAL FY REQ (FY 1985) = [AUTH STR (Per IFV BN) (264 ea E1/E4, 92 ea E5, 36 ea E6, 15 ea E7, 6 ea E8) x BN'S FIELDED (FY 1985) (2 ea BN's)] + [SCHOOL IVF'S RECEIVED (16 Veh ea) x AUTH STR PER SCHOOL VEHICLE (1 ea E1/E4, 1 ea E5, 1 ea E6, 0 ea E7, 0 ea E8)]

(544 ea E1/E4, 200 ea E5, 88 ea E6, 30 ea E7, 12 ea E8)

Total E1/E4 Req (FY 1985) (1,154) = Additional E1/E4 Req (FY 1985) (544) + Total E1/E4 Req (FY 1984) (610)

TABLE 13

TOTAL AND ADDITIONAL FY ENLISTED REQUIREMENTS BY GRADE: A1
(EUROPE)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)
FY / Rank	1982	1983	1984	1985	1986	1987	1988	1989	1990
E1/E4	0	0	792	1320	1320	2376	3168	4224	5544
	0	0	792	528	0	1056	792	1056	1320
E5	0	0	276	460	460	828	1104	1472	1932
	0	0	276	184	0	368	276	368	460
E6	0	0	108	180	180	324	432	576	756
	0	0	108	72	0	144	108	144	180
E7	0	0	45	75	75	135	180	240	315
	0	0	45	30	0	60	45	60	75
E8	0	0	18	30	30	54	72	96	126
	0	0	18	12	0	24	18	24	30

NOTE: Total personnel requirements/additional FY requirements

EXAMPLE:

ADDITIONAL FY REQ (FY 1985)

$$\begin{pmatrix} 528 \text{ ea E1/E4} \\ 184 \text{ ea E5} \\ 72 \text{ ea E6} \\ 30 \text{ ea E7} \\ 12 \text{ ea E8} \end{pmatrix} = \begin{pmatrix} 264 \text{ ea E1/E4} \\ 92 \text{ ea E5} \\ 36 \text{ ea E6} \\ 15 \text{ ea E7} \\ 6 \text{ ea E8} \end{pmatrix} \times (2 \text{ ea BN's})$$

AUTH STR (Per IFV BN)

BN'S FIELDED (FY 1985)

Total E1/E4 Req (FY 1985) (1,320) = Additional E1/E4 Req (FY 1985) (528) + Total E1/E4 Req (FY 1984) (792)

TABLE 14

TOTAL AND ADDITIONAL FY OFFICER REQUIREMENTS BY GRADE: A1
(COMBINED CONUS/EUROPE)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)
FY / Rank	1982	1983	1984	1985	1986	1987	1988	1989	1990
LT	0 / 0	35 / 35	116 / 81	208 / 92	254 / 46	438 / 184	599 / 161	783 / 184	944 / 161
CAPT	0 / 0	15 / 15	50 / 35	90 / 40	110 / 20	190 / 80	260 / 70	340 / 80	410 / 70
MAJ	0 / 0	5 / 5	16 / 11	28 / 12	34 / 6	58 / 24	79 / 21	103 / 24	124 / 21

NOTE: Total personnel requirements/additional FY requirements

EXAMPLE:

ADDITIONAL FY REQ (FY 1985)		AUTH STR (Per IFV BN)		BN'S FIELDED (FY 1985)
92 ea LT 40 ea CAPT 12 ea MAJ	=	23 ea LT 10 ea CAPT 3 ea MAJ	x	(4 ea BN's)

Total LT Requirements (FY 1985) (208)	=	Additional LT Requirements (FY 1985) (92)	+	Total LT Requirements (FY 1984) (116)

TABLE 15

ENLISTED PERSONNEL TRANSITIONED EACH FY BY GRADE: A1
(CONUS)

	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)
Rank \ FY	82	83	84	85	86	87	88	89	90
E1/E4	0	434	145	578	578	1156	1156	1156	578
E5	0	65	22	86	86	172	172	172	86
E6	0	48	16	64	64	128	128	128	64
E7	0	18	6	24	24	48	48	48	24
E8	0	6	2	8	8	16	16	16	8

Example: PERSONNEL TRANSITIONED (FY 1985) | AVERAGE ON-HAND BN STRENGTHS BY GRADE (CONUS) | NUMBER OF MECH INF BNS TRANSITIONED IN FY 1985 (CONUS)

$$\begin{pmatrix} 578 \text{ ea E1/E4} \\ 86 \text{ ea E5} \\ 64 \text{ ea E6} \\ 24 \text{ ea E7} \\ 8 \text{ ea E8} \end{pmatrix} = \begin{pmatrix} 289 \text{ ea E1/E4} \\ 43 \text{ ea E5} \\ 32 \text{ ea E6} \\ 12 \text{ ea E7} \\ 4 \text{ ea E8} \end{pmatrix} \times (2 \text{ ea BN'S})$$

3. Input Requirement Computations f(t)

The computational steps (i) through (iv) outlined in Section II were used to derive the input requirements for enlisted and officer personnel for FY 1982 through FY 1990. Data structure required three separate iterations of equation (3): Enlisted (CONUS), Enlisted (Europe), and Officer (Combined).

a. Enlisted Computations (CONUS)

(i) $[r(1) - Qc(1)]^{+} = f(1)$

$$\left\{ \begin{pmatrix} 47 \\ 47 \\ 47 \\ 0 \\ 0 \end{pmatrix} - \begin{bmatrix} 0.655 & - & - & - & - \\ 0.105 & 0.493 & - & - & - \\ - & 0.222 & 0.761 & - & - \\ - & - & 0.127 & 0.786 & - \\ - & - & - & 0.113 & 0.735 \end{bmatrix} \times \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} \right\}^{+} = \begin{pmatrix} 47 \\ 47 \\ 47 \\ 0 \\ 0 \end{pmatrix}$$

TABLE 16

ENLISTED PERSONNEL TRANSITIONED EACH FY BY GRADE: A1
(EUROPE)

	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)
Rank \ FY	82	83	84	85	86	87	88	89	90
E1/E4	0	0	651	434	0	868	651	868	1085
E5	0	0	129	86	0	172	129	172	215
E6	0	0	102	68	0	136	102	136	170
E7	0	0	30	20	0	40	30	40	50
E8	0	0	24	16	0	32	24	32	40

Example: PERSONNEL TRANSITIONED (FY 1985) — AVERAGE ON-HAND BN STRENGTHS BY GRADE (EUROPE) — NUMBER OF MECH INF BNS TRANSITIONED IN FY 1985 (EUROPE)

$$\begin{pmatrix} 434 \text{ ea E1/E4} \\ 86 \text{ ea E5} \\ 68 \text{ ea E6} \\ 20 \text{ ea E7} \\ 16 \text{ ea E8} \end{pmatrix} = \begin{pmatrix} 217 \text{ ea E1/E4} \\ 43 \text{ ea E5} \\ 34 \text{ ea E6} \\ 10 \text{ ea E7} \\ 8 \text{ ea E8} \end{pmatrix} \times (2 \text{ ea BN'S})$$

TABLE 17

OFFICER PERSONNEL TRANSITIONED EACH FY BY GRADE: A1
(CONUS AND EUROPE)

	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)
Rank \ FY	82	83	84	85	86	87	88	89	90
LT	0	27	63	72	36	144	126	144	126
CAPT	0	14	32	36	18	72	63	72	63
MAJ	0	3	7	8	4	16	14	16	14

Example: PERSONNEL TRANSITIONED (FY 1985) — AVERAGE ON-HAND BN STRENGTHS BY GRADE — TOTAL NUMBER OF MECH INF BNS TRANSITIONED IN FY 1985

$$\begin{pmatrix} 72 \text{ ea LT} \\ 36 \text{ ea CAPT} \\ 8 \text{ ea MAJ} \end{pmatrix} = \begin{pmatrix} 18 \text{ ea LT} \\ 9 \text{ ea CAPT} \\ 2 \text{ ea MAJ} \end{pmatrix} \times (4 \text{ ea BN'S})$$

(ii) $f(1) + Qc(1) = s(1)$

$$\left\{\begin{pmatrix}47\\47\\47\\0\\0\end{pmatrix} + \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \times \begin{pmatrix}0\\0\\0\\0\\0\end{pmatrix}\right\} = \begin{pmatrix}47\\47\\47\\0\\0\end{pmatrix}$$

(iii) $[r(2) - Qs(1) - Qc(2)]^{+} = f(2)$

$$\left\{\begin{pmatrix}475\\217\\133\\23\\9\end{pmatrix} - \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \begin{pmatrix}47\\47\\47\\0\\0\end{pmatrix}\right.$$

$$\left. - \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \begin{pmatrix}434\\65\\48\\18\\6\end{pmatrix}\right\}^{+}$$

$$= \begin{pmatrix}159\\110\\35\\-4\\2\end{pmatrix}^{+} = \begin{pmatrix}159\\110\\35\\0\\2\end{pmatrix}$$

(iv) $f(2) + Q[s(1) + c(2)] = s(2)$

$$\left\{\begin{pmatrix}159\\110\\35\\0\\2\end{pmatrix} + \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \times \left[\begin{pmatrix}47\\47\\47\\0\\0\end{pmatrix}\right.\right.$$

$$\left.\left. + \begin{pmatrix}434\\65\\48\\18\\6\end{pmatrix}\right]\right\} = \begin{pmatrix}474\\216\\133\\27\\9\end{pmatrix}$$

Steps (iii) and (iv) were then repeated for time periods 3 through 9.

b. Enlisted Computations (Europe)

Since no requirements existed for time periods 1 and 2, and zero personnel were transitioned, vectors f(1), s(1) and f(2), s(2)

would equal 0. Procedural steps (i) through (iv) would commence with time period 3 (t = 3).

(i) $[r(3) - Qc(3)]^{+} = f(3)$

$$\left\{\begin{pmatrix}792\\276\\108\\45\\18\end{pmatrix} - \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \times \begin{pmatrix}651\\129\\102\\30\\24\end{pmatrix}\right\}^{+}$$

$$= \begin{pmatrix}365\\144\\1\\8\\-3\end{pmatrix}^{+} = \begin{pmatrix}365\\144\\1\\8\\0\end{pmatrix}$$

(ii) $f(3) + Qc(3) = s(3)$

$$\left\{\begin{pmatrix}365\\144\\1\\8\\0\end{pmatrix} + \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \times \begin{pmatrix}651\\129\\102\\30\\24\end{pmatrix}\right\} = \begin{pmatrix}792\\276\\108\\45\\21\end{pmatrix}$$

(iii) $[r(4) - Qs(3) - Qc(4)]^{+} = f(4)$

$$\left\{\begin{pmatrix}1320\\460\\180\\75\\30\end{pmatrix} - \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \begin{pmatrix}792\\276\\108\\45\\21\end{pmatrix}\right.$$

$$\left. - \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \begin{pmatrix}792\\276\\108\\45\\21\end{pmatrix} \times \begin{pmatrix}434\\86\\68\\20\\16\end{pmatrix}\right\}^{+}$$

$$= \begin{pmatrix}516\\152\\-35\\1\\-5\end{pmatrix}^{+} = \begin{pmatrix}516\\152\\0\\1\\0\end{pmatrix}$$

(iv) $f(4) + Q[s(3) + c(4)] = s(4)$

$$\left\{\begin{pmatrix}516\\152\\0\\1\\0\end{pmatrix} + \begin{bmatrix}0.655 & - & - & - & -\\0.105 & 0.493 & - & - & -\\ - & 0.222 & 0.761 & - & -\\ - & - & 0.127 & 0.786 & -\\ - & - & - & 0.113 & 0.735\end{bmatrix} \times \left[\begin{pmatrix}792\\276\\108\\45\\21\end{pmatrix} + \begin{pmatrix}434\\86\\68\\20\\16\end{pmatrix}\right]\right\} = \begin{pmatrix}1319\\460\\215\\75\\35\end{pmatrix}$$

Steps (iii and (iv) were then repeated for time periods 5 through 9.

c. Officer Computations (Combined CONUS/Europe)

Since no requirements for officers existed during time period 1 (t = 1), and no officer personnel were transitioned, vectors f(1) and s(1) equaled 0. Procedural steps (i) through (iv) commenced with time period 2 (t = 2).

(i) $[r(2) - Qc(2)]^{+} = f(2)$

$$\left\{\begin{pmatrix}35\\15\\5\end{pmatrix} - \begin{bmatrix}0.768 & - & -\\0.182 & 0.786 & -\\ - & 0.123 & 0.804\end{bmatrix} \times \begin{pmatrix}27\\14\\3\end{pmatrix}\right\}^{+} = \begin{pmatrix}14\\-1\\0\end{pmatrix}^{+} = \begin{pmatrix}14\\0\\0\end{pmatrix}$$

(ii) $f(2) + Qc(2) = s(2)$

$$\left\{\begin{pmatrix}14\\0\\0\end{pmatrix} + \begin{bmatrix}0.768 & - & -\\0.182 & 0.786 & -\\ - & 0.123 & 0.804\end{bmatrix} \times \begin{pmatrix}27\\14\\3\end{pmatrix}\right\} = \begin{pmatrix}35\\16\\5\end{pmatrix}$$

(iii) $[r(3) - Qs(2) - Qc(3)]^{+} = f(3)$

$$\left\{\begin{pmatrix}116\\50\\16\end{pmatrix} - \begin{bmatrix}0.768 & - & -\\0.182 & 0.786 & -\\ - & 0.123 & 0.804\end{bmatrix} \times \begin{pmatrix}35\\16\\5\end{pmatrix} - \begin{bmatrix}0.768 & - & -\\0.182 & 0.786 & -\\ - & 0.123 & 0.804\end{bmatrix} \times \begin{pmatrix}63\\32\\7\end{pmatrix}\right\}^{+} = \begin{pmatrix}40\\-6\\0\end{pmatrix}^{+} = \begin{pmatrix}40\\0\\0\end{pmatrix}$$

(iv) $f(3) + Q[s(2) + c(3)] = s(3)$

$$\left\{\begin{pmatrix}40\\0\\0\end{pmatrix} + \begin{bmatrix}0.768 & - & -\\0.182 & 0.786 & -\\ - & 0.123 & 0.804\end{bmatrix} \times \left[\begin{pmatrix}35\\16\\5\end{pmatrix} + \begin{pmatrix}63\\32\\7\end{pmatrix}\right]\right\} = \begin{pmatrix}116\\56\\16\end{pmatrix}$$

Steps (iii) and (iv) were then repeated for time periods 4 through 9.

4. Assumption 1 Results

The following tables show the predicted training input flow requirements for enlisted and officer personnel when Mechanized Infantry Battalions are issued IFV's in accordance with the previously stated fielding schedule. These flows would maintain the newly formed IFV Battalions at an ALO 2 personnel strength level from FY 1982 through FY 1990.

TABLE 18

ENLISTED TRAINING INPUT REQUIREMENTS BY FY (A1)

		f(1)	f(2)	f(3)	f(4)	f(5)	f(6)	f(7)	f(8)	f(9)
Rank \ FY		82	83	84	85	86	87	88	89	90
E1/E4	C	47	159	204	375	573	887	1252	1615	1831
	E	0	0	365	516	456	942	1184	1580	2067
	T	47	159	569	891	1029	1829	2436	3196	3898
E5	C	47	110	83	167	222	324	400	476	472
	E	0	0	144	152	94	286	314	419	542
	T	47	110	227	319	316	610	714	895	1014
E6	C	47	35	0	0	0	0	0	0	0
	E	0	0	1	0	0	0	0	0	0
	T	47	35	1	0	0	0	0	0	0
E7	C	0	0	0	0	0	0	0	0	0
	E	0	0	8	1	0	0	0	0	0
	T	0	0	8	1	0	0	0	0	0
E8	C	0	2	1	2	0	1	0	0	0
	E	0	0	0	0	0	0	0	0	0
	T	0	2	1	2	0	1	0	0	0

NOTE: C = CONUS, E = Europe, T = Total

Table 18 shows that in FY 1982, 47 new recruits need to be trained in the 11M OSUT course at Fort Benning, Georgia. An additional 47 E5 and E6 11B's need to be retrained by means of in-route (transient) IFV programs.

TABLE 19

OFFICER TRAINING INPUT REQUIREMENTS BY FY (A1)

	f(1)	f(2)	f(3)	f(4)	f(5)	f(6)	f(7)	f(8)	f(9)
FY / Rank	82	83	84	85	86	87	88	89	90
LT	0	14	40	63	66	132	165	212	245
CAPT	0	0	0	0	0	0	0	0	0
MAJ	0	0	0	0	0	0	0	0	0

This table shows that no additional Captains or Majors need to be initially IFV trained by means of the Fort Benning In-Route (transient) course. New Liuetenant accessions into the IFV training pipeline, and NETT team training would more than adequately fulfill officer manpower requirements.

D. APPLICATION OF ASSUMPTION 2

An alternative approach to fielding the IFV is to take full advantage of all vehicles being produced each year. For example, as per Table 7, 108 IFV's are produced and received in CONUS units in FY 1983. Instead of fielding 1.5 battalions as did the first application (Section II, C), 2 battalions were fielded, consisting of the authorized 54 vehicles apiece. Table 20 shows the fielding breakdown by production schedule for each fiscal year.

TABLE 20

IFV BATTALIONS FIELDED BY FY (CONUS/EUROPE)

Fiscal Year	82	83	84	85	86	87	88	89	90
CONUS	0.0	2.0	0.0	2.5	2.0	4.0	4.25	3.75	1.5
EUROPE	0.0	1.25	2.0	2.0	0.5	4.0	3.5	4.0	4.0
TOTAL	0.0	3.25	2.0	4.5	2.5	8.0	7.75	7.75	5.5

NOTE: One quarter (0.25) of a battalion equates to a company size unit.

The mathematical computations which follow are identical in structure to those used in Assumption 1 (Section C).

1. Total Requirement Vector Computation r(t)

Using formula (8) on page 38, Tables 21, 22, and 23 show total enlisted and officer personnel requirements (by grade) during each fiscal year for CONUS and Europe.

2. Transition Vector Computation c(t)

Transition requirements were determined in the same manner as Assumption 1. However, in this instance, the data contained in Table 20 (battalions fielded in accordance with the IFV production schedule) was used. Applying formula (9) on page 38 to these data resulted in the tabulated vectors in Tables 24, 25, and 26.

3. Assumption 2 Results

As in the models' first aplication (Assumption 1), computational steps (i) through (iv) were used, resulting in Tables 27 and 28 showing the enlisted and officer training input requirements for FY 1982 through FY 1990.

TABLE 21

TOTAL AND ADDITIONAL FY ENLISTED REQUIREMENTS BY GRADE: A2
(CONUS)

Rank \ FY	r(1) 1982	r(2) 1983	r(3) 1984	r(4) 1985	r(5) 1986	r(6) 1987	r(7) 1988	r(8) 1989	r(9) 1990
E1/E4	47	607	610	1291	1845	2901	4021	5014	5406
	47	560	3	681	554	1056	1120	933	392
E5	47	263	266	514	724	1092	1483	1829	1966
	47	216	3	248	210	368	391	346	137
E6	47	151	154	261	359	503	656	792	846
	47	104	3	107	98	144	153	136	54
E7	0	30	30	68	98	158	222	279	302
	0	30	0	38	30	60	64	57	23
E8	0	12	12	28	40	64	90	113	122
	0	12	0	16	12	24	26	23	9

NOTE: Total personnel requirements/additional FY requirements.

TABLE 22

TOTAL AND ADDITIONAL FY ENLISTED REQUIREMENTS BY GRADE: A2
(EUROPE)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)
Rank \ FY	1982	1983	1984	1985	1986	1987	1988	1989	1990
E1/E4	0	333	861	1389	1526	2582	3502	4558	5614
	0	333	528	528	137	1056	920	1056	1056
E5	0	116	300	484	532	900	1221	1589	1957
	0	116	184	184	48	368	321	368	368
E6	0	46	118	190	209	353	479	623	767
	0	46	72	72	19	144	126	144	144
E7	0	19	49	79	87	147	200	260	320
	0	19	30	30	8	60	53	60	60
E8	0	8	20	32	36	60	81	105	129
	0	8	12	12	4	24	21	24	24

NOTE: Total personnel requirements/additional FY requirements.

TABLE 23

TOTAL AND ADDITIONAL FY OFFICER REQUIREMENTS BY GRADE: A2
(COMBINED CONUS/EUROPE)

	r(1)	r(2)	r(3)	r(4)	r(5)	r(6)	r(7)	r(8)	r(9)
Rank \ FY	1982	1983	1984	1985	1986	1987	1988	1989	1990
LT	0	75	121	225	283	467	646	825	952
	0	75	46	104	58	184	179	179	127
CAPT	0	33	53	98	123	203	281	359	414
	0	33	20	45	25	80	78	78	55
MAJ	0	10	16	30	38	62	86	110	127
	0	10	6	14	8	24	24	24	17

NOTE: Total personnel requirements/additional FY requirements

TABLE 24

ENLISTED PERSONNEL TRANSITIONED EACH FY BY GRADE: A2
(CONUS)

	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)
FY / Rank	82	83	84	85	86	87	88	89	90
E1/E4	0	578	0	723	578	1156	1229	1084	434
E5	0	86	0	108	86	172	183	162	65
E6	0	64	0	80	64	128	136	120	48
E7	0	24	0	30	24	48	51	45	18
E8	0	8	0	10	8	16	17	15	6

TABLE 25

ENLISTED PERSONNEL TRANSITIONED EACH FY BY GRADE: A2
(EUROPE)

	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)
FY / Rank	82	83	84	85	86	87	88	89	90
E1/E4	0	272	434	434	109	868	760	868	868
E5	0	54	86	86	22	172	151	172	172
E6	0	43	68	68	17	136	119	136	136
E7	0	13	20	20	5	40	35	40	40
E8	0	10	16	16	4	32	28	32	32

TABLE 26

OFFICER PERSONNEL TRANSITIONED EACH FY BY GRADE: A2
(CONUS AND EUROPE)

	c(1)	c(2)	c(3)	c(4)	c(5)	c(6)	c(7)	c(8)	c(9)
FY / Rank	82	83	84	85	86	87	88	89	90
LT	0	59	36	81	45	144	140	140	99
CAPT	0	30	18	41	23	72	70	70	50
MAJ	0	7	4	9	5	16	16	16	11

TABLE 27

ENLISTED TRAINING INPUT REQUIREMENTS BY FY (A2)

		f(1)	f(2)	f(3)	f(4)	f(5)	f(6)	f(7)	f(8)	f(9)
Rank \ FY		82	83	84	85	86	87	88	89	90
E1/E4	C	47	197	212	417	620	934	1316	1670	1836
	E	0	154	357	540	544	1014	1312	1695	2060
	T	47	351	569	957	1164	1948	2628	3365	3896
E5	C	47	131	72	188	232	334	420	482	459
	E	0	60	119	157	124	302	351	444	519
	T	47	191	191	345	356	636	771	926	978
E6	C	47	36	0	0	0	0	0	0	0
	E	0	1	0	0	0	0	0	0	0
	T	47	37	0	0	0	0	0	0	0
E7	C	0	0	0	0	0	0	0	0	0
	E	0	3	3	0	0	0	0	0	0
	T	0	3	3	0	0	0	0	0	0
E8	C	0	3	0	2	0	1	1	0	0
	E	0	0	0	0	0	0	0	0	0
	T	0	3	0	2	0	1	1	0	0

NOTE: C = CONUS, E = Europe, T = Total

TABLE 28

OFFICER TRAINING INPUT REGUIREMENTS BY FY (A2)

	f(1)	f(2)	f(3)	f(4)	f(5)	f(6)	f(7)	f(8)	f(9)
Rank \ FY	82	83	84	85	86	87	88	89	90
LT	0	29	35	69	75	135	180	220	243
CAPT	0	0	0	0	0	0	0	0	0
MAJ	0	0	0	0	0	0	0	0	0

E. COMPARISON OF ASSUMPTIONS 1 AND 2

A cursory review of the resulting personnel input requirements from Assumptions 1 and 2 (Tables 18, 19, 27, and 28) reveals an approximate balancing of manpower needs from year to year. This was somewhat surprising considering Assumption 2 provides for the fielding of 41.25 IFV Battalions as compared to the predetermined number of 41 shown in Assumption 1. A close look at the total input requirements of the two assumptions over the nine-year period, by grade, portrayed a noticeably different picture, especially in the lower enlisted and officer grades.

TABLE 29

TOTAL INPUT REQUIREMENTS BY GRADE
(FY 1982 THROUGH FY 1990)

Rank	Using Assumption 1 (Predetermined Schedule)	Using Assumption 2 (Production Schedule)
E1/E4	14,054	14,925
E5	4,252	4,441
E6	83	84
E7	9	6
E8	6	7
LT	937	986
CAPT	0	0
MAJ	0	0

In both applications, the model does not allow for the carrying forward of excess inputs from year to year. An excellent example of this was the enlisted computations (Europe) on page 45 for f(3) which resulted in (-3) E8 inputs. Since all flows must be positive, this negative flow was replaced with a zero. An overview of the total number of excess IFV trained personnel produced by both fielding assumptions for FY's 1982 through 1990 is depicted in Table 30.

TABLE 30

EXCESS TRAINED PERSONNEL BY GRADE

Rank	Using Assumption 1 (Predetermined Schedule)	Using Assumption 2 (Production Schedule)
E1/E4	0	0
E5	0	0
E6	2,387	2,150
E7	727	642
E8	99	100
LT	0	0
CAPT	484	537
MAJ	183	213

The zero excess of personnel in the grade of E5, for either application, resulted from the approximate doubling of authorized billets under the new IFV Battalion TO & E. Aside from this fact, the remaining differences between the assumptions are either expected or lacked significance.

The most noticeable differences in the two assumptions lie in comparing the utilization of IFV's produced. Assumption 1 did not make maximum use of the vehicles produced each fiscal year. Table 31 depicts this disparity between the assumptions.

F. INSTRUCTOR REQUIREMENTS

The IFV Model assumption computations described in Sections C and D provide manpower planners with an estimate of personnel needs to meet future 11M requirements. The assumptions did not, however, address two factors which would generate added personnel training loads: new recruit attrition from the 11M course and internal training for personnel advancing in grade and responsibility (i.e., 11M gunner's course for E5's and 11M

TABLE 31

IFV's SITTING IDLE EACH FY

Fiscal Year	Using Assumption 1 (Predetermined Schedule)	Using Assumption 2 (Production Schedule)
1982	0	0
1983	95	0
1984	0	0
1985	28	0
1986	28	0
1987	0	0
1988	39	0
1989	0	0
1990	0	0

commander's course for E6's). The additional training load generated by these factors was combined with the projected input requirements produced by Assumption 1 and Assumption 2 before determining overall instructor needs. To illustrate this process, the enlisted input flows of Assumption 1, depicted in Table 18, were used. Though not shown, officer computations would be executed in a like manner.

The U.S. Army Infantry School divided 11M instructional responsibilities between two training groups: the Infantry Training Group (ITG) and the Weapons Group. Their specific course responsibilities, the length of courses, approximate number of flows per fiscal year, and desired student to instructor ratios are depicted in Table 32.

1. ITG Instructor Requirements

The total enlisted training input requirements for new 11M recruits for FY 1982 through FY 1990 (extracted from Table 18) are reflected in Table 33.

TABLE 32

11M INSTRUCTIONAL DATA

Component	Course	Length	Flows/FY	Ratio
ITG	OSUT	3 weeks*	5	6 to 1
Weapons Group	In-Route E5	4 weeks	8	2 to 1
Weapons Group	In-Route E6, E7, E8	6 weeks	8	2 to 1

*The 11M course is presently designed as a 3-week add-on course running concurrently with the 11B course. Course duration is 14 weeks.

NOTE: Component responsibilities, course lengths, and instructor ratios reflect current IFV Task Force policy; flows per fiscal year were estimates for demonstation purposes only [Ref. 3].

TABLE 33

NEW RECRUIT 11M OSUT INPUT REQUIREMENTS

Fiscal Year	82	83	84	85	86	87	88	89	90
OSUT INPUT	47	159	569	891	1029	1829	2436	3196	3898

NOTE: Table shows only total E1/E4 requirements.

An attrition rate (5.8%) from a like OSUT training course (Improved TOW Vehicle) was used to compute the anticipated loss of new recruits in the 11M program.[7] The revised input training requirements necessary to produce the projected number of trained 11M personnel portrayed in Table 33 are shown in Table 34.

[7]The attrition rate, provided by the IFV Task Force, was computed from the following Improved TOW Vehicle Course FY 1980 data: number of personnel who successfully completed the course (690), divided by the number who started (733).

TABLE 34

11M OSUT REVISED INPUT REQUIREMENTS
(DATA ARE NUMBER OF PERSONNEL)

Fiscal Year	82	83	84	85	86	87	88	89	90
OSUT INPUT	50	169	603	944	1090	1937	2579	3384	4127

Using the pertinent information provided in Table 32 (OSUT flows and student to instructor ratio), instructor requirements for each FY were computed for the revised input training loads.

TABLE 35

OSUT INSTRUCTOR REQUIREMENTS BY FY

Fiscal Year	82	83	84	85	86	87	88	89	90
STUDENTS PER FLOW	10*	34	121	189	218	388	516	677	826
NUMBER OF INSTRUCTORS	2	6	21	32	37	65	104	113	166

*Students would probably be incorporated into one flow.

NOTE: A lesser number of instructors would be needed if flows per FY were increased. Much would depend on existing facilities and class size.

2. Weapons Group Instructor Requirements

The number of E4 personnel requiring the E5 gunner's course each FY was calculated in the following manner:

Stocks of E4 11M's remaining from the previous FY $s(t)$, $t=1,\ldots 8$	x	Fraction of E4's who moved to E5 (taken from the Q matrix) 0.105	=	Anticipated number of E4's who will require the gunner's course in a given FY

Likewise, the projected numbers of E5 personnel requiring the E6 IFV commander's course each FY was determined using the following formula:

Stocks of E5 11M's remaining from the previous FY s(t), t=1,...8	x	Fraction of E5's who moved to E6 (taken from the Q matrix) 0.222	=	Anticipated number of E5's who will require the commander's course in a given FY

Using the stocks s(t) computed from Assumption 1, the numbers of personnel requiring the IFV gunner's or commander's course are depicted in Table 36.

TABLE 36

IFV GUNNER AND COMMANDER COURSE REQUIREMENTS BY FY
(DATA ARE NUMBER OF PERSONNEL)

		FY	82	83	84	85	86	87	88	89	90
	GUN	C	0	5	50	64	122	180	291	401	512
CONUS	NER	E	0	0	0	84	139	139	250	333	444
		T	0	5	50	148	261	319	541	734	956
	CMD	C	0	11	48	59	104	150	232	314	395
SE	R	E	0	0	0	62	103	103	184	245	327
		T	0	11	48	121	207	253	416	559	722

NOTE: C = CONUS, E = Europe, T = Total.

Example [s(2) computation, FY 1983, on page 44.]

Stocks of E4 11M's remaining from the previous FY s(2)		Fraction of E4's who were promoted		Anticipated number of E4's requiring gunner training in FY 1984
(474)	x	(0.105)	=	$49.8 \approx \underline{50}$

Stocks of E5 11M's remaining from the previous FY s(2)		Fraction of E5's who were promoted		Anticipated number of E5's requiring CMDR's course in FY 1984
(216)	x	(0.222)	=	47.9 ≈ 48

The total FY input requirements for E5's amd E6's depicted in Table 18 were then combined with the internal training requirements shown in Table 36 (using total figures from each table) resulting in the following revised FY training input table (Table 37).

TABLE 37

REVISED TRAINING INPUT REQUIREMENTS FOR E5 AND E6
(BY FY)

Fiscal Year	82	83	84	85	86	87	88	89	90
E5	47	115	277	467	577	929	1255	1629	1970
E6	47	46	49	121	207	253	416	559	722
TOTAL	94	161	326	588	784	1182	1671	2188	2692

From the data presented in Table 37, the instructor requirements for the Weapons Group were derived (Table 38).

TABLE 38

WEAPONS GROUP INSTRUCTOR REQUIREMENTS
(BY FY)

Fiscal Year	82	83	34	85	86	87	88	89	90
STUDENTS PER FLOW	12	21	41	74	98	148	209	274	337
NUMBER OF INSTRUCTORS	6	11	21	37	49	74	105	137	169

NOTE: The combined E5 and E6 totals per FY were used in the computation. Owing to their expected small numbers, E7 and E8 personnel were not considered in the instructor requirement computations.

IV. CONCLUSIONS AND RECOMMENDATIONS

This thesis documents the methodology and analysis associated with designing a manpower model for the introduction of the IFV into the Army's inventory. The model's purpose is to forecast annual flow of personnel into the IFV training programs established at Fort Benning, Georgia. The model provides manpower planners with the capability of testing alternative IFV fielding proposals and adjusting model parameters to improve the use of limited personnel resources.

Two fielding proposals illustrate separate applications of the IFV model. These are: (a) Assumption 1, predetermined numbers of Mechanized Infantry Battalions would be issued IFV 's from FY 1982 through FY 1990 and the current production schedule would be reviewed to insure an adequate number of vehicles will be available for issue each fiscal year; and (b) Assumption 2, the annual production of IFV's would dictate the number of battalions fielded during any given fiscal year.

The model provides the IFV planner with a comparative analysis of the long-range impact of these assumptions on personnel and vehicle resources. Assumption 1 resulted in 9.4 percent less E1 through E4 and 9.6 percent less E5 IFV trained personnel over the nine year period than did Assumption 2. At the same time, Assumption 1 generated larger quantities of excess trained personnel in the grades E5 and E6 (See Table 30) than did Assumption 2. However, the model also shows that approximately 8 percent of the IFV's produced during the nine year fielding process would remain unissued using Assumption 1, as compared to a 100 percent vehicle

utilization with Assumption 2. These results assume that the FMC Corporation, designer of the IFV, maintains the current production and receipt schedule outlined in Appendix A.

The IFV model described here does not incorporate all aspects of the integration process. As with any simulation, it was necessary to stipulate assumptions and limitations. For example, retention and attrition are estimates based on past longitudinal behavioral data. Care has been taken to state important assumptions, but the user must read computational results with the knowledge that the figures are subject to future changes in behavior patterns and may not be precise predictions of the future.

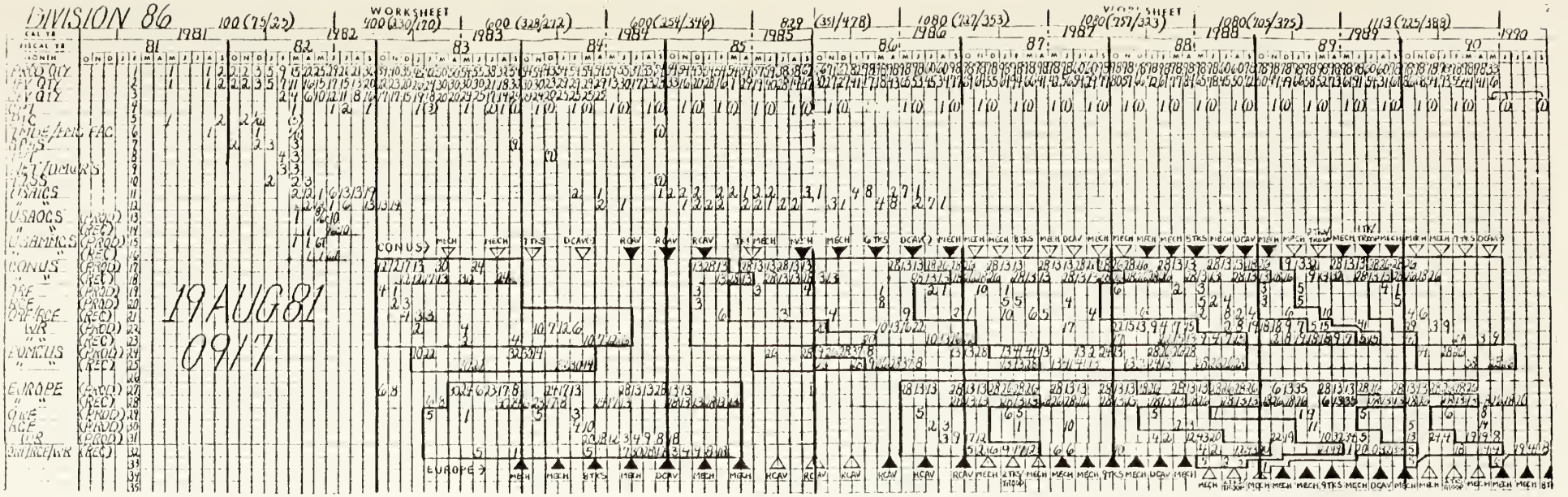
Although useful as a planning tool in its present design, there are further improvements which would enhance the versatility and accuracy of the IFV model:

1. Adaptation of the model to existing computer technology so that alternative policies could be investigated rapidly.
2. A more precise and expeditious method of accumulating pertinent longitudinal raw data for development of the model's Q-matrix (a pre-established report, with the proper categorical breakdown, was not readily avalable and data was manually extracted from numerous strength reports).
3. With the introduction of a new military occupational specialty (11M), an excellent opportunity exists for establishing a cohort which, when tracked for a period of time, would render valuable personnel movement trends. This would greatly enhance the accuracy and reliability of the fractional flow Q-matrix and resulting output of the IFV model.

4. Instead of using average on-hand strength figures for computing the transition vectors c(t), substitute the actual numbers of personnel on-hand in units designated to be retrained by the NETT team during that given year. Initiation of this consideration would have to commence in the beginning of the IFV planning cycle, and be followed through on an annual basis.

The methodology and analysis conducted in this research has potential in applications to other IFV and Cavalry Fighting Vehicle MOS's with the ultimate goal of designing manpower models for each.

Modelling is rapidly becoming an integral part of the increasingly complex and dynamic environment of the manpower planner. The ultimate acceptance and use of any model depends largely on understanding its design. This thesis is presented with the user in mind, emphasizing the importance of a detailed understanding of the factors that influence planning in a manpower system.



(Production schedule provided by the IFV Task Force, Fort Benning, Georgia.)

List of Acronyms

CPT	Contractor Production Test
PTC	Physical Tear Down
TMDE	Test Measure Diagnostic Equipment
FMC FAC	Producers Facility
SPAS	Skill Performance Aids
IPT	Initial Production Test
DMWR's	Depot Maintenance Work Requirement
T2SS	Total 2 Sub Systems
USAICS	Infantry School
USAOCS	Officer Candidate School
USAMMCS	Missile School
CONUS	Continental United States
ORF/RCF	Floats
WR	War Reserves
POMCUS	Prepositioning of Materials Configured to Unit Sets

LIST OF REFERENCES

1. Bigelman, Paul A. "Force Designs for the Future," Army, June, 1981.

2. Army Regulation 310-25, Military Publication Dictionary of United States Army Terms, 15 September, 1975.

3. Hobson, G. K., Maj. and Hagberh, K. SFC, Personnel Communications, Infantry Fighting Vehicle Task Force Headquarters, Fort Benning, Georgia, September, 1981.

4. Tice, J., "Fighting Vehicle, Named for Bradley, Unveiled," Army Times, 2 November 1981.

5. Ludvigsen, Eric C., "IFV: Gestation Long, Painful, But Product Is Superior," Army, June, 1979.

6. Morris, Ernest Lewis, An Analysis of Officer Professional Development in the VP (Maritime Patrol) Aviation Community with Application of an Interactive Computer Model for Seatour Opportunity Determination, M.S. Thesis, Naval Postgraduate School, Monterey, June 1980.

7. Marshall, Kneale T. and Grinold, Richard C., Manpower Planning Models, Elsevier-North Holland, New York, 1977.

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